Transmission Line Magnet Cost Elements

- General Comments
- M&S vs. Labor
- Manufacturing Models
- 2-D Cross Section Parts Costs
- Elements of System Costs
- Escalation, Contingency etc.

Feel-Good Comments

- It is not necessary to decide which VLHC magnet is cheapest in order to conclude that the superconducting synchrotron is provides the most E_{CM} per $.
- Magnet M&S is a good starting point and a reasonable predictor of total magnet costs.

Feel-Uncomfortable Comments

- We have sold the VLHC R&D program as one that is focussed on cost reductions for a technologically mature machine.
- We have yet to make the case that the R&D directions that are being pursued will result in an overall cheaper machine, even if they succeed.
- ➡ *Need new iterations of total system design. It's NOT just the magnets.*

M&S vs. Labor Costs: Some Recent Dipoles

- RHIC Phase II Dipoles: M&S = 62%
- Main Injector Dipoles: M&S = 93%
- Recycler Dipoles: M&S = 86%
- LHC Dipoles ??

- Magnet costs seem to hover between 1.1 and 1.5 x parts cost.

When can M&S costs be trusted?

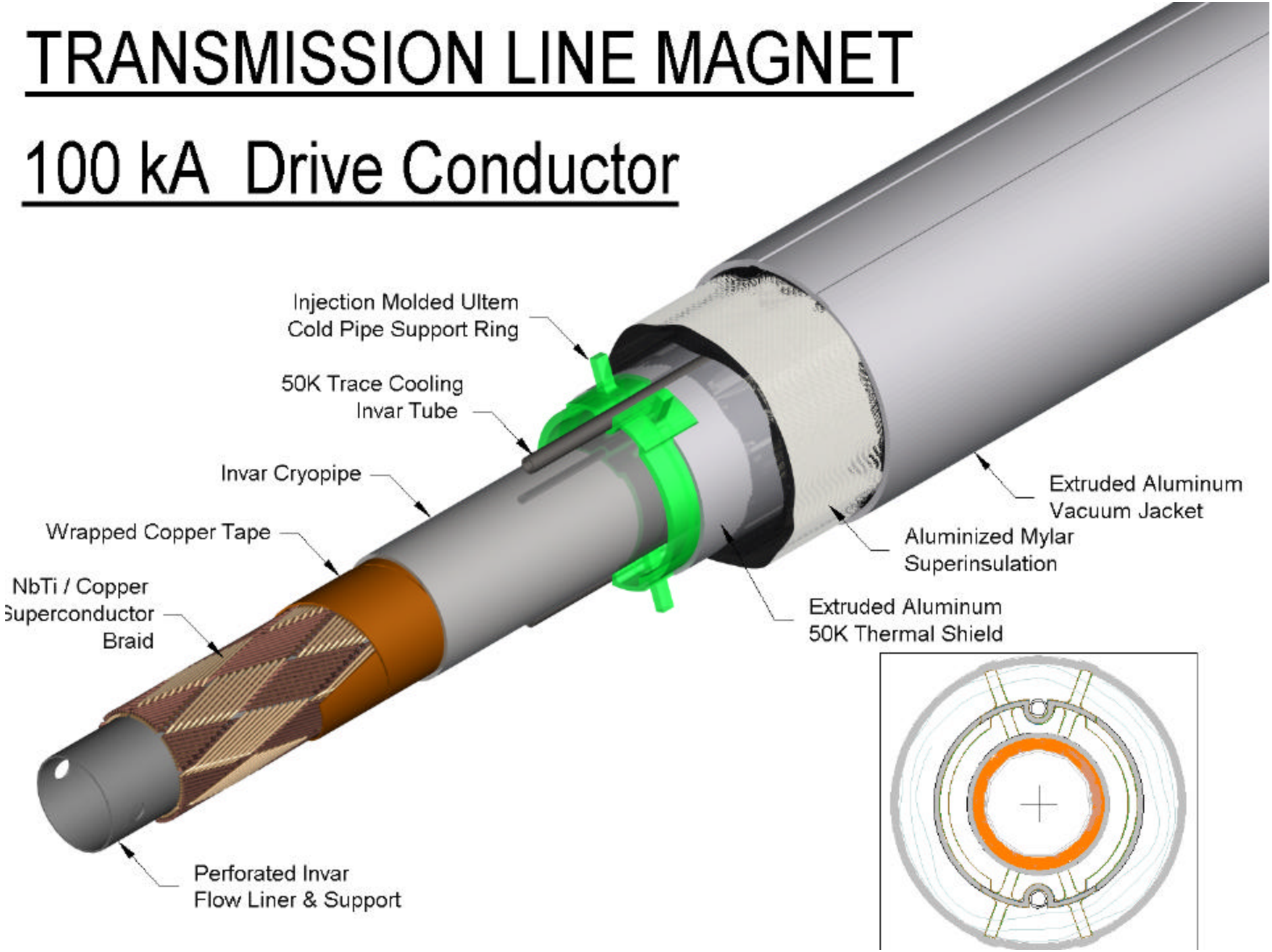
- Commodity High Volume Product
- Commercial Tolerances
- Multiple quotes from experienced vendors
- Complete, tested design exists.

Examples where you can trust M&S Costs

- Stainless Steel Piping
- Iron Lamination Stacks
- Injection Molded Plastic Parts
- Aluminum Extrusions
- Structural Steel Tubing
- NbTi SC Strand
- Coaxial Cable

TRANSMISSION LINE MAGNET

100 kA Drive Conductor



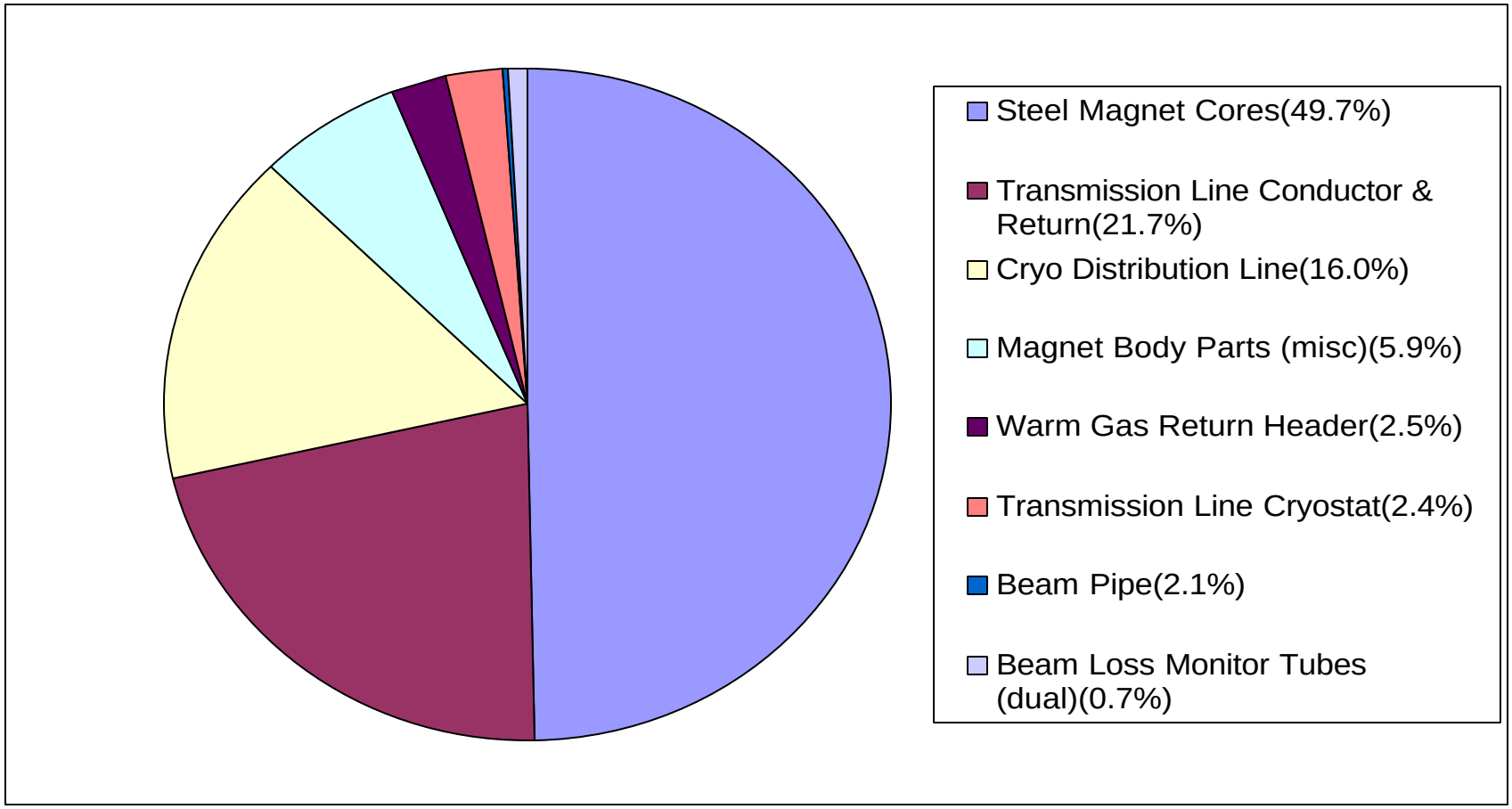
When Can you NOT trust M&S Cost Estimates?

- No Proven Design Exists: (example: Old Gap Spacer design for LF Mag)
- No Experienced Vendor Exists (example: X-Band Cavities for NLC)
- Required Tolerances are outside of normal commercial practice
- Fundamental parameters are open: (example: aperture)

LF VLHC MAGNET COSTS

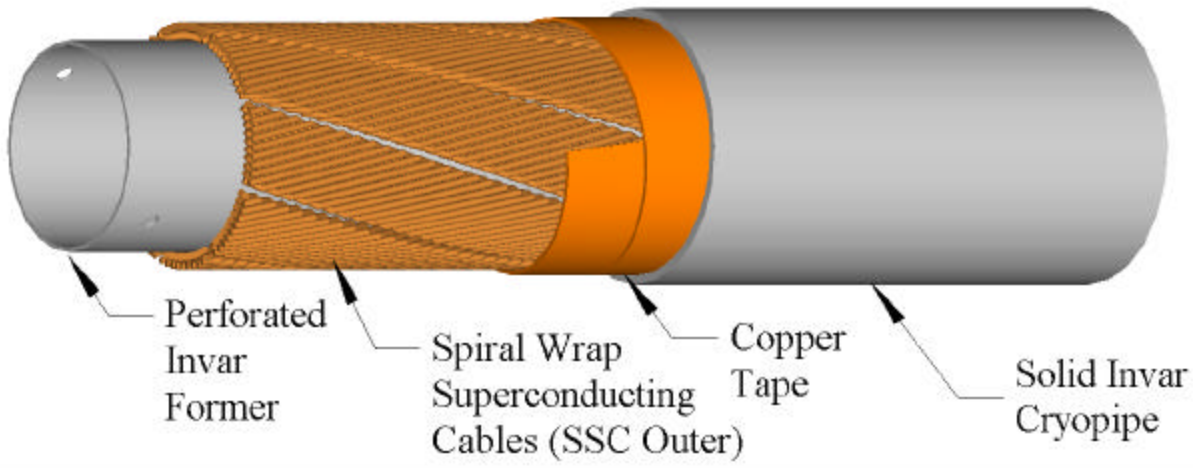
- Most of the 2-D cross section (Magnet Body) parts are commercial parts in the “Well Known” category.
- Many of the magnet end parts are not so well known, but these should be a small fraction of the total. The magnets are long.

2-D Magnet Body Costs

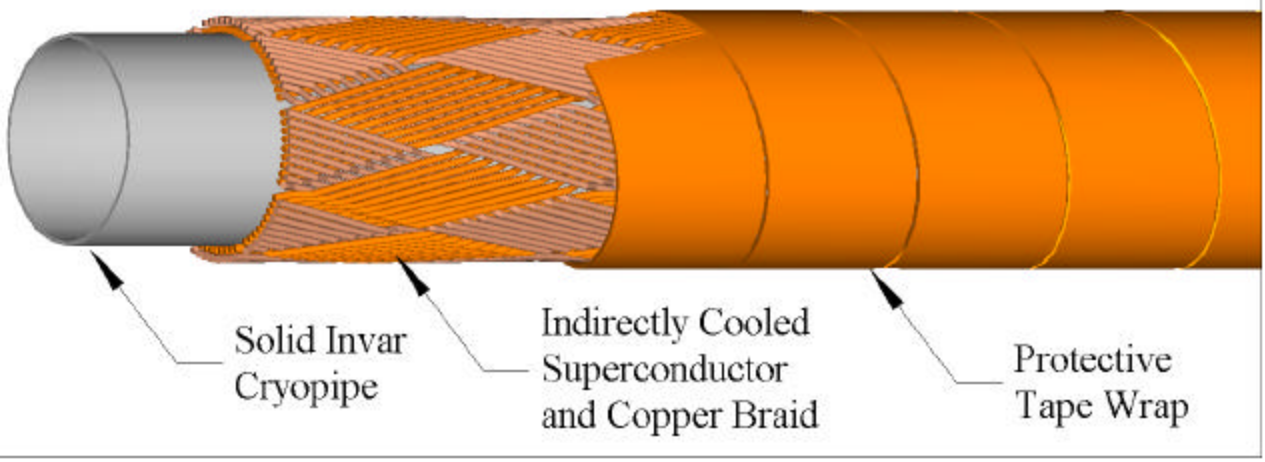


TRANSMISSION LINE CONDUCTOR DESIGNS

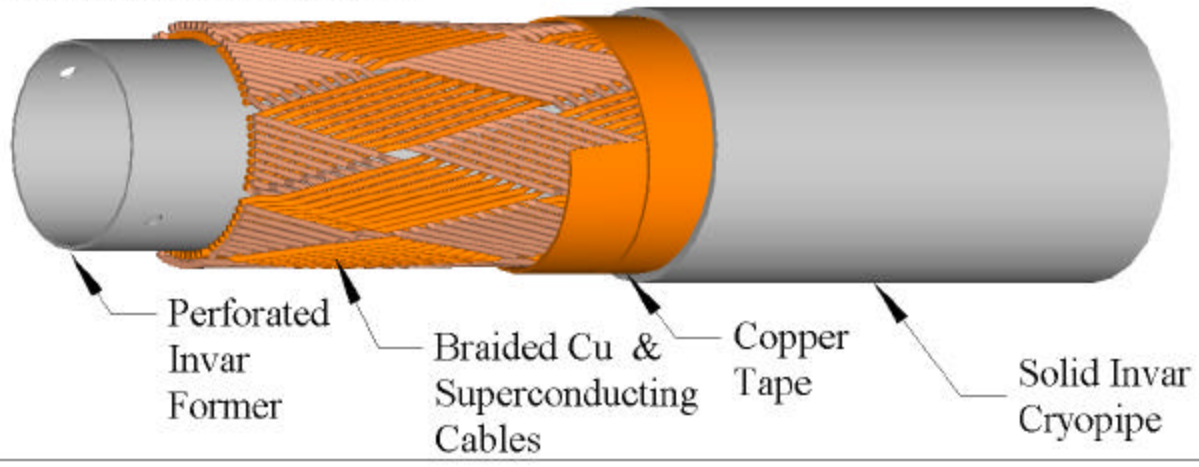
BASELINE (Rutherford Cable-in-Conduit) DESIGN



KEK (Indirectly Cooled Braid) DESIGN



HYBRID DESIGN



Going Offshore

- Many of the steel parts are substantially cheaper from non-US sources. (factor of ~2/3).
- If we do this, the 2-D magnet body parts will be less than $1k/m (=$10M/TeV)
- SSC solution: purchase the parts offshore and call it a “foreign contribution”. (?)

Corrector Magnets

- Most expensive and power hungry “magnet end part” is corrector.
- Air-cooled pancake coils with iron laminations.
- Costs based on Main Injector correctors, scaled for weight of coil and iron.
- No need for LCW system in tunnel.

Manufacturing

- Buy completed Iron Lamination Stacks from vendors.
- Buy pipes and tubes in truck-sized (40’) lengths.
- Final Assembly on-site as FMI.
- Weld together into ~125m assemblies which include all magnet instrumentation, cables, correctors, etc.

Transport and Installation

- Making a magnet moving vehicle for 125m magnets will be fun. Hook & Ladder Truck technology.
- The magnet vehicle will also transport long pre-assembled lengths of warm-gas return header and power conduit.
- Use vehicle to align magnets.

What is needed to get to a system cost estimate?

- The low-field “magnet” will include many “accelerator” costs such as quads, cables, correctors, quench protection, instrumentation.
- If the goal is to develop a standalone cost estimate for the LF VLHC, this make things easy. In process for 3 TeV study.
- If the goal is to do a relative cost comparison with cold-iron magnets, costs for these magnet-dependent subsystems will have to be developed.